Report SAM-TR-80-26

LEVEL II

2

CREW STRESS AND FATIGUE IN THE PAVE LOW III SYSTEM

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USAF SCHOOL OF AEROSPACE MEDICINE
Aerospace Medical Division (AFSC)
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NOTICES

This final report was submitted by personnel of the Crew Performance Branch, Crew Technology Division, USAF School of Aerospace Medicine, Aerospace Medical Division, AFSC, Brooks Air Force Base, Texas, under job order 7930-10-28.

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The operational personnel who participated in this study were fully briefed on all procedures prior to participation in the study.

This report has been reviewed by the Office of Public Affairs (PA) and is releasable to the National Technical Information Service (NTIS). At NTIS, it will be available to the general public, including foreign nations.

This technical report has been reviewed and is approved for publication.

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The purpose of the PAVE LOW III system is to demonstrate that helicopter crews can perform combat rescue at night and in marginal weather conditions. This report discusses the PAVE LOW III system crew stress and fatigue and human factors problems encountered during combat simulated exercises. From the subjective fatigue (SF) data and self-report rating scales it appears that the system significantly stressed experienced test pilots. Workload was extremely demanding of pilot attention, skill, and alertness during terrain following/terrain avoidance, approach to hovering, and hovering maneuvers.

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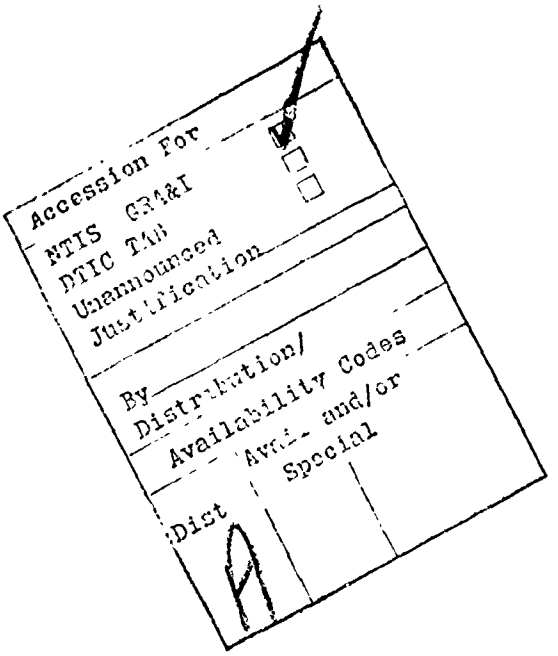
20. ABSTRACT (Continued)

It is recommended that the maximum flying time should be no more than 6 hours for these types of missions, and there should be at least 8 hours of uninterrupted sleep or 12 hours of crew rest between missions. Attention should be given to improving the following features: seating, acoustic insulation, display illumination, maps and holders, and communication and ventilation systems.



CREW STRESS AND FATIGUE IN THE PAVE LOW III SYSTEM

INTRODUCTION

The PAVE LOW III system consists of a terrain following radar, forward looking infrared (FLIR) sensor, inertial navigation system, Doppler radar set, and a projected map display (PMD) integrated through a central avionics computer into a night recovery system equipped HH53B helicopter. The system was developed in response to MAC ROC 19-70. The purpose of the system is to perform combat rescue at night and in marginal weather conditions.

The demands of the system coupled with the increased mission risk profile for which PAVE LOW was designed could impose a relatively high level of stress on the crew. The U.S. Air Force School of Aerospace Medicine (USAFSAM) was asked to evaluate the crew stress, fatigue, and human factors problems encountered during such missions; determine the maximum flying time and crew duty day limitations, crew rest requirements, and recovery period time for repetitive missions; and evaluate safety factors.

This report presents the findings of highly experienced trained pilots associated with four PAVE LOW III missions flown during one Blue Flag and two Red Flag exercises (Table 1). Red Flag exercises, conducted at Nellis AFB NV, involved simulated air combat for training of aircrews. Both ground-to-air and air-to-air combat missions were simulated. The terrain at Nellis AFB is mountainous and rough with complex topography. Environmentally it is hot and dry. Blue Flag was conducted at Eglin AFB FL and involved command and control decision training in simulated combat exercises. Sometimes flight tactics were also involved. The terrain at Eglin AFB is of low-level beach areas with simple topography. Environmental stressors are heat, fog, and humidity. All four rescue missions were conducted at night.

PROCEDURES

A battery of psychobiological and human factors measures was used to evaluate crew fatigue and human factors problems. The battery consisted of self ratings of subjective fatigue (Appendix A), sleep and activity analysis surveys (Appendix B), postflight questionnaire (Appendix C), self-report environmental and human engineering rating scales (Appendix D), system satisfaction checklist (Appendix E), and a critical incident report form (Appendix F). Cockpit temperatures, body temperatures, and heart rate were continuously monitored on an inflight data recorder. In field studies these measures are unobtrusive, easy to collect, and cost effective, and require no specialized psychological data collection techniques, bulky instrumentation, or modification of aircraft and pilot equipment.

Subjective fatigue scores are based on both relative values and absolute scores. The subjective fatigue data result in mean scores ranging from 0 - 20, of which 12 and above indicate feelings of alertness, mean scores of 11

TABLE 1. FLIGHT SCENARIOS

Exercise	Type of flight	Flight hours	Flight times	Dates	Survivors rescued	Terrain type	Environment
1st Red Flag	PAVE LOW	6.3	1700-2400	28 Aug 78	2	Mountainous, rough with complex topography	Hot, dry
	Return	3.3	1400-1800	29 Aug 78	N/A	"	"
2nd Red Flag#1	PAVE LOW	3.5	1500-1900	29 Nov 78	2	"	"
" #2	"	3.3	1500-1900	30 Nov 78	2	"	"
Blue Flag	PAVE LOW	3.3	1700-2100	23 Jun 78	2	Low-level, beach area	Hot, humid, and fog

down to 8 relate to moderate fatigue, and mean scores of 7 and lower indicate severe fatigue. The sleep and activity analysis survey documents the total hours slept and spent on various activities during each 24-hour period. Both the subjective fatigue and the sleep and activity analysis questionnaires were used for one month prior to the PAVE LOW III missions to collect baseline data on the crew during nonflying or flight training duty days.

Self-report rating scales (1) were used to elicit quantitative judgments from crews concerning the adequacy of various bioenvironmental and human engineering aspects of the PAVE LOW III system being tested. The scales supplemented objective data that couldn't be secured to determine the crew's reactions to the PAVE LOW III system. (See Appendix D for examples.) The following system characteristics were evaluated: vibration discomfort, environmental conditions (noise, temperature/humidity), illumination, flight control quality, display readability, control accessibility, control-display arrangement, information presented by displays, communications, operating procedures, and operator workload. The scales provided information on the amount of effort a pilot or crew expended and/or the difficulty experienced in fulfilling the PAVE LOW III system mission. Each scale has five reference points representing a continuum ranging from excellent (1.0) through good (2.5), fair (4.0), and poor (5.5) to unacceptable (7.0). A behavioral descriptor identifies or "anchors" each point. Crews were asked to check the appropriate position on the scale, paying particular attention to the behavioral descriptors. In addition, a satisfaction checklist (Appendix E) was used to supplement the preceding individual scales concerning the adequacy of various aspects of the PAVE LOW III system.

A critical incident report (Appendix F) and a postflight questionnaire (Appendix C) were used to evaluate the overall mission, flight experience, and any unusual event such as equipment breakdown occurring during systems operation. The critical incident report covered symptoms, diagnosis, causes, and proposed remedies to any problems. The postflight questionnaire indicated how the pilot felt about the PAVE LOW III system, conditions, fatigue state, motivation, difficulty of a situation, and any problems experienced.

Heart rate is a means of measuring the "physiological cost" of sustained/continuous operation, as it is sensitive to the acute and cumulative tension felt by an individual. During both Red Flag exercises heart rate was measured using a USAFSAM Medilog recorder. The Medilog recorder is an ultra-slow tape drive, 4-channel cassette tape recorder adapted for high amplifier gain operation that recorded electrocardiogram (ECG) and body skin temperature of the pilots. The heart-rate data were scored on a minute-by-minute basis from a polygraph paper record.

The test crew consisted of 3 helicopter pilots, 2 highly experienced and trained pilots and 1 recently trained for the PAVE LOW III system. The 2 highly experienced PAVE LOW III pilots flew the first Red Flag exercise, the first PAVE LOW flight test of the second Red Flag exercise, and the Blue Flag exercise. The newly trained pilot participated in only the second PAVE LOW flight test of the second Red Flag exercise.

RESULTS/DISCUSSION

First Red Flag Exercise

The first Red Flag exercise in which the PAVE LOW III System participated was a simulated rescue mission of 6.3 hours duration conducted on the night of 28 August 1978. The PAVE LOW helicopter had deployed from Kirtland AFB NM at 1700 hours on 28 August and arrived the same day at 2400 hours. Two night refuelings and one rescue of 2 survivors were accomplished before landing at Nellis AFB NV. The tanker aircraft was at the wrong location for the first refueling, which caused additional stress in searching through the rough terrain around Nellis AFB NV. Table 1 shows the airborne time intervals for these flights.

On the return flight, 29 August 1978, the PAVE LOW III helicopter flew from Nellis AFB NV, back to Kirtland AFB NM, performing routine terrain following/terrain avoidance (TF/TA) maneuvers for 3.3 hours. Refueling or rescue tactics were not scheduled for this return flight. Subjective fatigue and sleep survey data were collected on the return flight and also on the next day, termed recovery day, 30 August 1978, at Kirtland AFB NM.

Subjective fatigue (SF) scores indicated that both pilots were considerably fatigued upon completion of the PAVE LOW III mission (Fig. 1). The SF score of 5.75 at 2000 hours on 28 Aug 1978 was the lowest mean value reported for SF during this study. This indicates considerable acute fatigue resulted from this first Red Flag exercise of 6.3 hour total flight time. For the return flight day on 29 Aug 1978 an indication of cumulative fatigue was reported with the SF mean value of 10.00 at 0800 hours when compared with the near mean score of 14.00 for baseline data at 0800 hours. This SF score was collected 6 to 8 hours after the completion of the PAVE LOW III mission. The return flight day SF level for 2000 hours was similar to the SF for baseline levels at 2000 hours, namely, near the mean value of 10.00, on which days no flying was experienced. Table 2 presents the various SF mean levels by time of day for each exercise described in Figure 1.

Sleep survey data indicated an average of 8 hours of sleep prior to the mission, 6 hours of sleep following the mission at Nellis AFB and prior to the return flight, and 7.5 hours of sleep the next day after the return flight. Both pilots reported that no more sleep was needed as a result of this mission.

The postflight questionnaire data indicated that both pilots compared the PAVE LOW III mission to stressful combat night missions in Southeast Asia. They reported that TF/TA and the hovering segments of the flight were very demanding of their attention, skill, and alertness. This is interpreted to indicate that a high level of workload is required for certain flight maneuvers during a PAVE LOW III mission. Both pilots reported their overall performance to be good.

The human factors self-report rating scales were analyzed by averaging the numerical values checked by both pilots and relating that value to the scale descriptors. The responses are presented in Figure 2. The illumination

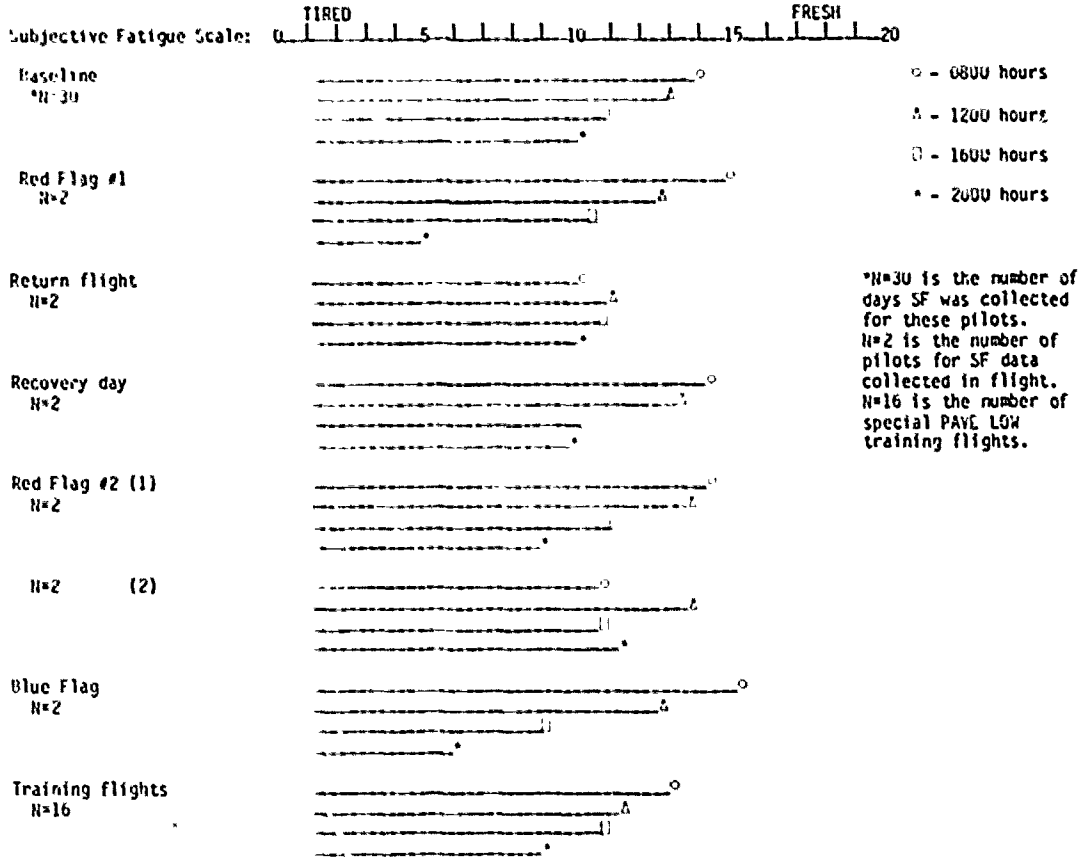


Figure 1. Mean subjective fatigue scores for PAVE LOW III.

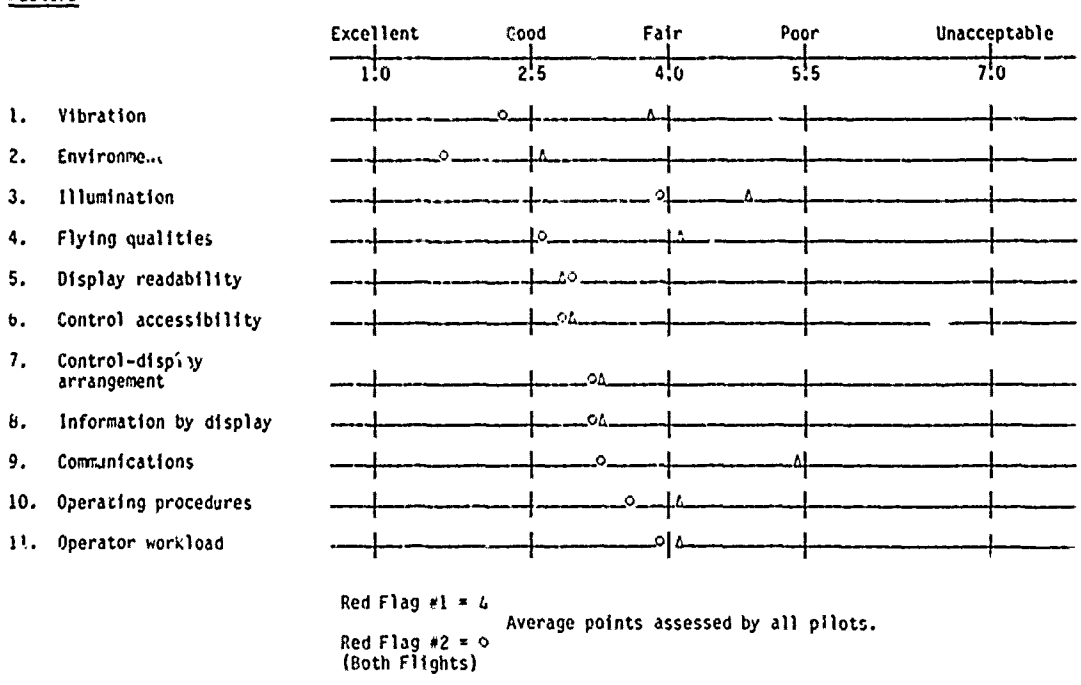


Figure 2. Human factors self-report rating scale data.

TABLE 2. SUBJECTIVE FATIGUE MEANS FOR PAVE LOW III

Mission	N	Time of Day			
		0800	1200	1600	2000
Baseline[a]	30	13.67	13.17	11.33	9.92
Red Flag #1	2	14.50	13.00	10.50	5.75
Return flight	2	10.00	12.00	11.00	10.00
Recovery day	2	14.00	13.00	10.00	10.00
Red Flag #2					
1st flight	2	14.00	13.00	11.00	9.00
2nd flight	2	11.00	13.00	11.00	12.00
Blue Flag	2	14.50	13.00	9.00	7.00
PAVE LOW					
Flight days of training[b]	16	12.25	11.75	10.31	9.38

[a]Baseline Data means were collected from 30 different duty days in which no flying was done for these 3 pilots.

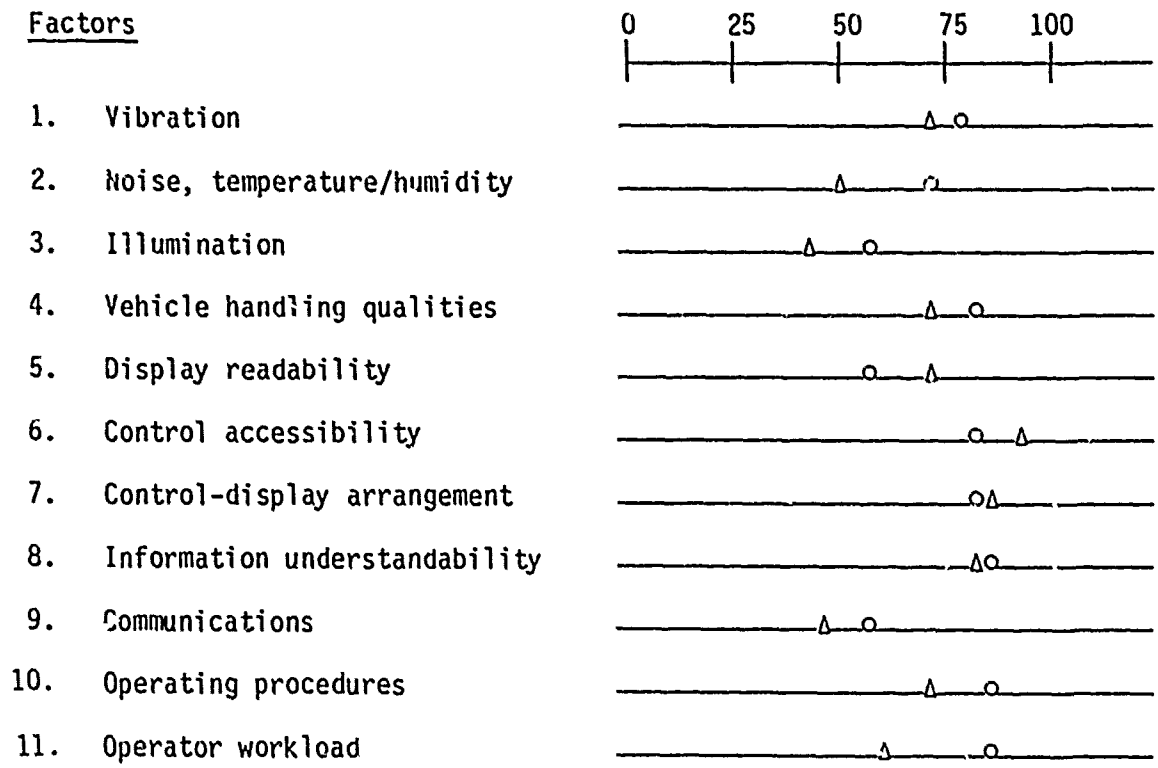
[b]Data means from PAVE LOW flight days of training for 3 pilots.

and display readability factors were rated as tasks that required moderate effort due to display and instrument lights being too bright. Also, communications were reported to be poor due to distortion of the intercom/radio messages between the crew. They rated workload to be of considerable effort and difficulty.

The satisfaction checklist scale was analyzed by averaging the numerical value checked by both pilots as to their degree of satisfaction or dissatisfaction with the previous factors individually rated. The reported slightly unsatisfactory factors were noise, temperature, illumination, and communications, and a slightly satisfactory factor of operator workload. These results are shown in Figure 3.

The critical incident report questionnaire indicated that the inertial navigation system was unaligned, thus preventing automated terrain following during the operation of PAVE LOW III. This could have resulted in an abnormal or potentially dangerous situation by the fact that it caused a diversion of attention from flying the helicopter.

Cockpit temperatures were measured and the results are presented in Table 3 for both the PAVE LOW III mission and the return flight. During the mission, the highest temperature recorded in the cockpit was 35°C (95°F) before takeoff at 1705 hours at Kirtland AFB NM. Ambient cockpit temperatures



NOTE: On a scale from 0 to 100, 0 represents complete dissatisfaction and 100 represents complete satisfaction.

Figure 3. Satisfaction checklist data.

ranged from a high of 35°C (95°F) before takeoff at 1705 hours at Kirtland AFB NM, to 26°C (79°F) before hovering at 2125 hours local time, tc 30°C (86°F) at 2355 hours on landing at Nellis AFB NV. Prior to the return flight cockpit temperatures reached a very hot, uncomfortable 45.6°C (114°F) when engines were turned on at 1405 hours at Nellis AFB NV. Fortunately, exposure time was for less than 10 minutes.

Heart rate measurements indicated that one of the pilots, who had considerable experience and training in the PAVE LOW III concept, was not stressed to an extent that his heart rate was significantly increased. The range was from 65 beats/min to 96 beats/min, flying a normal course to terrain following at 100 ft (30.48 m) respectively, as shown in Figure 4. The peak heart rate of 96 beats/min during the terrain following at 100 ft correlated with the pilots reporting the TF at 100 ft as their most stressful maneuver experienced.

TABLE 3. PAVE LOW III COCKPIT TEMPERATURES

RED FLAG # 1

Time	Temp °C	(°F)	Event
1705	35.0	95	Equipment check
1710	35.0	95	Start engines
1740	29.4	85	Takeoff From Kirtland AFB
2030	31.1	88	1st Refueling
2050	32.0	90	TF at 500 ft (152.4 m)
2125	26.0	79	Enter hovering
2145	26.0	79	Depart hovering
2225	28.0	83	2nd Refueling
2235	30.0	86	TF at 100 ft (30.48 m)
2304	30.0	86	Exit range at 100 ft
2355	30.0	86	Land at Nellis AFB

RETURN FLIGHT

1405	40.6°C	105°F	Equipment check
1411	41.7	107	Equipment check
1414	45.6	114	Start engines
1423	43.3	110	Takeoff from Nellis AFB
1440	31.1	88	2,000 ft (60.96 m)
1500	25.6	78	200 - 500 ft (60.96 - 152.4 m) TF
1600	26.1	79	"
1630	25.6	78	"
1700	19.4	67	"
1715	15.6	60	"
1730	18.3	65	"
1745	21.1	70	Approach landing
1747	22.2	72	Land at Kirtland AFB

Second Red Flag Exercise

The second Red Flag Exercise was conducted at Nellis AFB NV. The helicopter and crew were at Nellis AFB 3 days prior to their PAVE LOW III test mission. During this exercise data were collected from two consecutive night flights on 29 and 30 November 1978.

The first test flight consisted of 3.5 hours in which two survivors were rescued on one mission. Following the test flight, both pilots reported slight levels of subjective fatigue (Fig. 1 and Table 2) which were similar to the baseline data for typical work day circadian patterns. Sleep survey data indicated an average of 10 hours of sleep prior to the mission, and 8 hours of sleep following the mission.

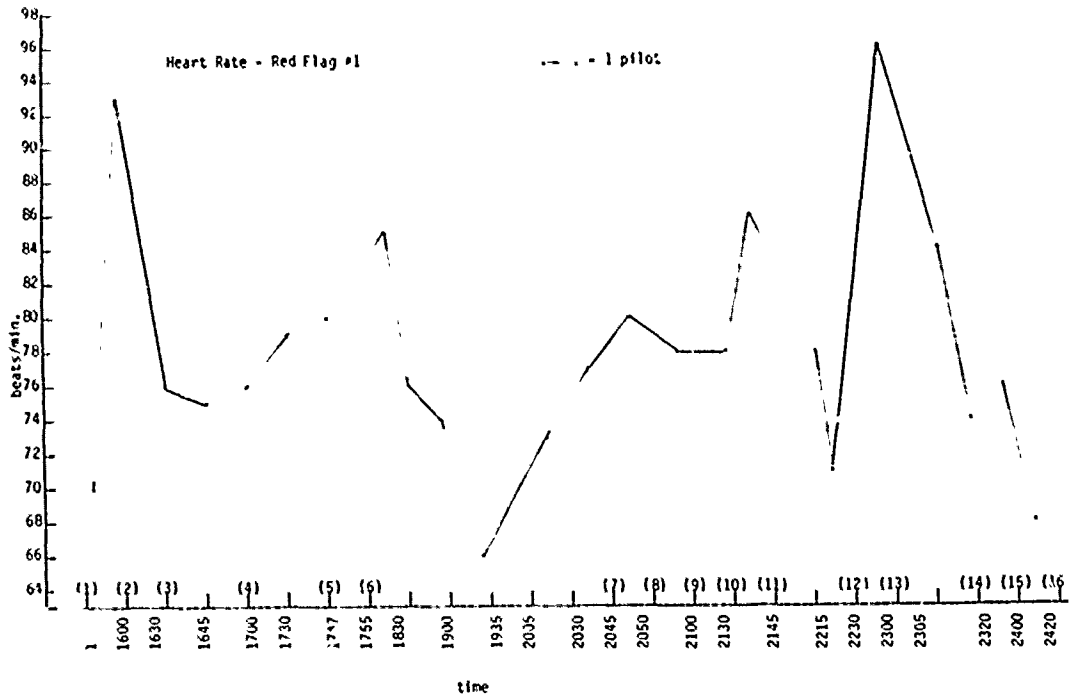


Figure 4. Pilot's heart rate during Red Flag #1.

Number	Time	Event
1	1550	Briefing
2	1600	Loading craft
3	1630-1645	Checking equipment
4	1710	Start engines
5	1747	Takeoff
6	1755-2030	In normal flight
7	2043	1st Refueling
8	2050	Start TF at 500 ft (152.4 m)
9	2100	TF - 500 ft (152.4 m)
10	2130	Enter hovering
11	2145	Departing from hovering
12	2230	2nd Refueling
13	2300-2315	Enter TF at 100 ft (30.48 m)
14	2320	Landing approach
15	2400	On the ground
16	2419	At debriefing center

The postflight questionnaire data indicated that additional stress resulted from being spatially disoriented as a result of FLIR malfunction during the hovering manuever. The crew also reported TF/TA, the approach to the hovering area, and the hovering segment to be very demanding of their attention, skill, and alertness; i.e., a high level of workload was required during these flight maneuvers. The maximum flight time recommended for NAP-of-the-earth type flight at very low altitudes and for instrument flying

missions at night was 3-4 hours by one pilot while the other pilot reported 6-7 hours. Both pilots rated their performance as good.

The results of human factors self-report rating scales are presented in Figure 2. Illumination was reported to be inadequate since tasks required excessive effort for fine visual discrimination. The main complaint was that certain instruments were too bright. Also, display readability was poor for some displays. Workload responses indicated that job effort varied from slight to considerable.

The satisfaction checklist in Figure 3 shows that pilots perceived illumination, display readability, and communications as slightly satisfactory. The critical incident report and the postflight questionnaire indicated that the Projected Map Display (PMD) was inoperable before takeoff and the FLIR elevation control became inoperable during hovering. The mission was completed without FLIR by staying above 200 ft (60.96 m) altitude. Heart rate and ambient cockpit temperature measurements were not available for this flight as a result of recording equipment malfunction.

The second flight was a 3.3-hour rescue mission of two survivors. The pilot was a recently trained PAVE LOW III system crewmember, while the copilot was one of the two highly experienced and trained pilots for this system. From the SF raw scores it appeared the pilot was more fatigued than the copilot. Sleep survey data reported an average of 8 hours of sleep prior to the mission and 8.5 hours of sleep following the mission. Both pilots reported they had adequate sleep.

The postflight questionnaire reported hovering and TF/TA as the most stressful manuevers, i.e., very demanding of their attention, skill, and alertness. Both pilots rated their overall mission performance as good.

The human factors self-report rating scales indicated the main problems to be illumination and operator workload (Fig. 2). The recently trained pilot reported that the operating procedures of PAVE LOW III system required moderate effort with some difficulty to understand and follow. He also reported the workload level to involve considerable effort and difficulty. The more experienced copilot, however, reported that he had no difficulty with the required PAVE LOW III system procedures. Apparently, because of his inexperience the pilot's workload demands were much higher than the copilot's.

The system satisfaction checklist indicated the pilots' slight satisfaction with illumination, display readability, and communications (Fig. 3). The critical incident report showed that the navigational computer heading locked up, thus, the loss of TF/TA commands on the FLIR monitor which made low-level flight more stressful and difficult at night. Ambient cockpit temperatures were not collected for this flight. Heart rate measurements on the copilot indicated the range to be from 67 to 118 beats/min with peak heart rates of 114 to 118 beats/min during approach to hovering and during hovering (Fig. 5). Other relatively higher rates were found during engine start (112 beats/min), shortly after takeoff (106 beats/min), and during TF at 200 ft (60.96 m) altitude (108 beats/min). The heart rate recordings of the pilot were lost due to equipment failure.

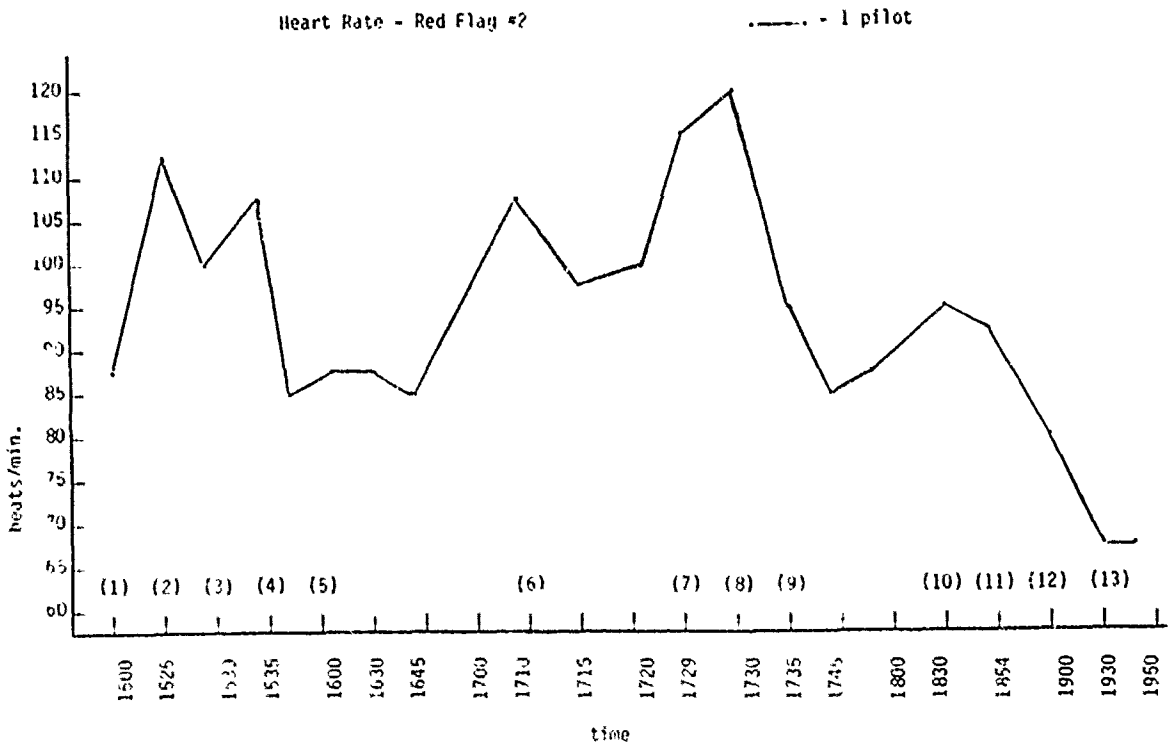


Figure 5. Copilot's heart rate during Red Flag #2.

Number	Time	Event
1	1550	Briefing
2	1525	Start engines
3	1530	Checking equipment
4	1535	Takeoff
5	1600-1700	In normal flight
6	1710	Start TF at 200 ft
7	1729	Approach to hovering
8	1730	Hovering
9	1735	Enter TF at 200 ft
10	1830	Landing approach
11	1854	Landing
12	1900	On the ground
13	1930	At debriefing center

Blue Flag Exercise

The Blue Flag Exercise consisted of a 3.3-hour flight test involving one rescue mission of two survivors. During the Blue Flag exercise at Eglin AFB FL, 23 June 1978, self-rating SF measures and activity analysis and sleep survey data were collected. A special interview of the two well-experienced and trained pilots was conducted after the flight. Results indicated that both pilots were severely fatigued, especially the copilot. Sleep survey data reported an average of 7.25 hours prior to the mission. Radar failure

increased flight stress. The aircrew complained about severe heat and humidity in the cockpit during the mission. Objective measures of body or cockpit temperature were not obtained; however, the crew was on the runway for 45 minutes before takeoff, with the outside temperature reported to be 95°F with 85% humidity. Both pilots rated their mission performances as fair. The copilot expressed an awareness of being very irritable and, as a consequence, making more mistakes. He recognized this as a symptom of fatigue. The crew reported that the greatest stress maneuver was "approach to hovering;" next was hovering.

The following conclusions resulted from personal interviews with the PAVE LOW flight crew during the Blue Flag exercises. Heat stress, radar system failure, approach to hovering position, hovering maneuver, low altitude terrain following and avoidance maneuvers, and pickup were considered to be the stressors that induced severe acute fatigue for both pilots during the 3.3-hour flight. The pilots were knowledgeable of the relationship between fatigue and performance decrement.

CONCLUSIONS

The first Red Flag exercise results for the PAVE LOW III system indicated that both pilots were considerably fatigued at the end of the 6.3-hour flight. They rated their mission as one of considerable effort and difficulty; TF/TA, for example, was completely demanding of their skill, alertness, and attention. Heart rate increase paralleled the subjective reporting of increasingly stressful flight tasks. Both pilots rated their performance as satisfactory in the sense that they completed a very difficult mission despite problems with the tanker rendezvous.

For the second and third Red Flag exercises the pilots (2 experienced and 1 recently trained) reported slight fatigue at the end of 3.5- and 3.3-hour missions. They reported their mission was difficult due to equipment failures, but rated their performance as good.

The results of the Blue Flag exercise demonstrated that both PAVE LOW III pilots were severely fatigued, especially the copilot. The radar failure added to the stress of the 3.3-hour flight. Also, severe heat and humidity were contributing factors. Self-rated performance was fair.

Symptoms of acute fatigue were expressed by the Blue Flag exercise pilots in recognized performance decrement ("making too many mistakes") and the feeling of irritability. Other studies (2, 3) described similar symptoms to acute fatigue in helicopter pilots. It became apparent during the interview of the Blue Flag exercise pilots that they could not replicate the flight test without some recovery time and crew rest, at least 12 hours. They expressed the need for crew sleep of 8 to 10 hours.

The personal interview suggested that there are changes in pilot-control performance as a function of intensified flight requirements such as represented by PAVE LOW III and corresponding pilot fatigue. It must be noted that the stresses on the pilot's performance were modest and not life threatening. Accumulative error related to stress and fatigue, however, takes on increased

importance when the small margin for error associated with PAVE LOW III missions is considered.

It appears that PAVE LOW III system did substantially stress experienced test pilots. The workload was extremely demanding of the pilot attention, skill, and alertness during TF/TA, approach-to-hovering, and hovering maneuvers. However, the pilots successfully carried out their required simulated combat rescue missions even though exposed to the added stresses of significant equipment failures.

Because of the apparent stressful demand of the PAVE LOW III system, it is recommended that the maximum flying time should be no more than 6 hours for highly trained and experienced pilots. Also, there should be at least 8 hours of uninterrupted sleep and 12 hours of crew rest between missions. At least 8 consecutive hours of sleep is likewise recommended for PAVE LOW missions of 2 to 4 hours.

Immediate attention is recommended for the amelioration of features of the aircrew task and environment which engender fatigue, such as: enhance seating with some reduction of transmitted vibration, increase acoustic insulation, improve instrumentation and controls display illumination, have better maps and holders for inflight use, rectify communications system for the entire crew, and improve ventilation system.

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APPENDIX A

SUBJECTIVE FATIGUE CHECKCARD

NAME AND GRADE		TIME/DATE	
INSTRUCTIONS Make one and only one (✓) for each of the ten items. Think carefully about how you feel RIGHT NOW.			
STATEMENT	BETTER THAN	SAME AS	WORSE THAN
1. VERY LIVELY			
2. EXTREMELY TIRED			
3. QUITE FRESH			
4. SLIGHTLY POOPED			
5. EXTREMELY PEPPY			
6 SOMEWHAT FRESH			
7. PETERED OUT			
8. VERY REFRESHED			
9. FAIRLY WELL POOPED			
10. READY TO DROP			

SAM FORM 136
SEP 76

SUBJECTIVE FATIGUE CHECKCARD

PREVIOUS EDITION WILL BE USED

APPENDIX B

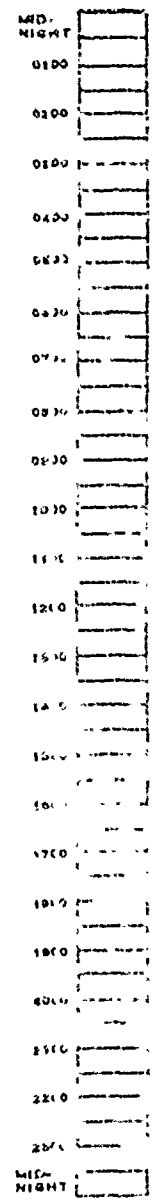
TIME ANALYSIS RECORD
PAVE LOW III FORM

TIME ANALYSIS RECORD - PAVE LOW III	DATE
NAME (Last, First, MI)	LOCATION (Base)

DIRECTIONS: Using the ACTIVITIES CODE LIST, place the proper code number for your predominant activity in each of the 48 half-hour blocks. Keep each day's record current.

ACTIVITIES CODE LIST

Code #	Code Item
1.	Sleeping
2.	Helicopter Flying - Pave Low
3.	Helicopter Flying - Instruction
4.	Helicopter Flying - Emergency/Alert
5.	Pre-Mission Briefing
6.	Post-Mission Briefing
7.	Other Briefings
8.	Desk/Administrative Activities
9.	Eating Meals
10.	Physical Activity (Sports)
11.	Leisure Activity
12.	Personal Chores and Grooming
13.	Shopping
14.	Partying
15.	Off-duty Employment
16.	Off-duty Education/Classes
17.	Job Related Education
18.	AF Related Instruction on Flying or Maintenance
19.	AF Duties not related to Flying or Maintenance
20.	Enroute Travel
X.	Other _____



IF FLYING, CHECK MISSION CONDITIONS: DAY _____ NIGHT _____ VMC _____
IMC _____ WIND TURBULENCE _____ HIGH ALTITUDE _____ TERRAIN FOLLOWING _____
AERIAL REFUELING _____ HOVERING _____ OTHER _____
CABIN CONDITIONS: HOT _____ COLD _____ COMFORTABLE _____
PLEASE USE THE BACK OF THIS FORM FOR REMARKS OR COMMENTS ON THIS DAY'S ACTIVITIES.

APPENDIX C

POSTFLIGHT QUESTIONNAIRE

NAME:_____ DATE:_____

1. What is the total flight time of this mission? _____

2. Was this mission similar in pilot workload to any missions you typically fly? _____

_____

_____

3. Have you ever flown a helicopter mission with this degree of stress or greater? _____

_____

4. How would you rate the difficulty of this mission (check one):

   a. Very Simple ____ b. Relatively Easy ____ c. Mildly Difficult ____

   d. Moderately Difficult ____ e. Very Difficult ____ f. Impossible ____

5. Compared to your usual flying do you feel you had a (check one):

   a. Good Day ____ b. Normal Day ____ c. Bad Day ____

6. How demanding was TF/TA of pilot's attention, skill, alert? (check one):

   a. Mild ____ b. Very ____ c. Completely ____ d. Nearly uncontrollable ____ e. Uncontrollable ____

7. How demanding was "approach to hovering area" of pilot's attention, skill, alert?

   a. Mild ____ b. Very ____ c. Completely ____ d. Nearly uncontrollable ____ e. Uncontrollable ____

8. How demanding was "hovering" of pilot's attention, skill, alert? (check one):

   a. Mild ____ b. Very ____ c. Completely ____ d. Nearly uncontrollable ____ e. Uncontrollable ____

POSTFLIGHT QUESTIONNAIRE
(Continued)

NAME: _____ DATE: _____

9. What should be the maximum flight time for NAP flying and instrument mission at night? _____

_____

10. Could you repeat this exercise again? ____ within 2 hours? ____ after 3 hrs? ____

11. Certain flight maneuvers or mission requirements are very stressful. Which maneuver of this mission was the worst? _____

_____

12. After "hovering," were you fatigued? _____

13. After "landing," were you fatigued? _____

14. How would you rate your performance? (check one) excellent ____, good ____, fair ____, poor ____.

APPENDIX D

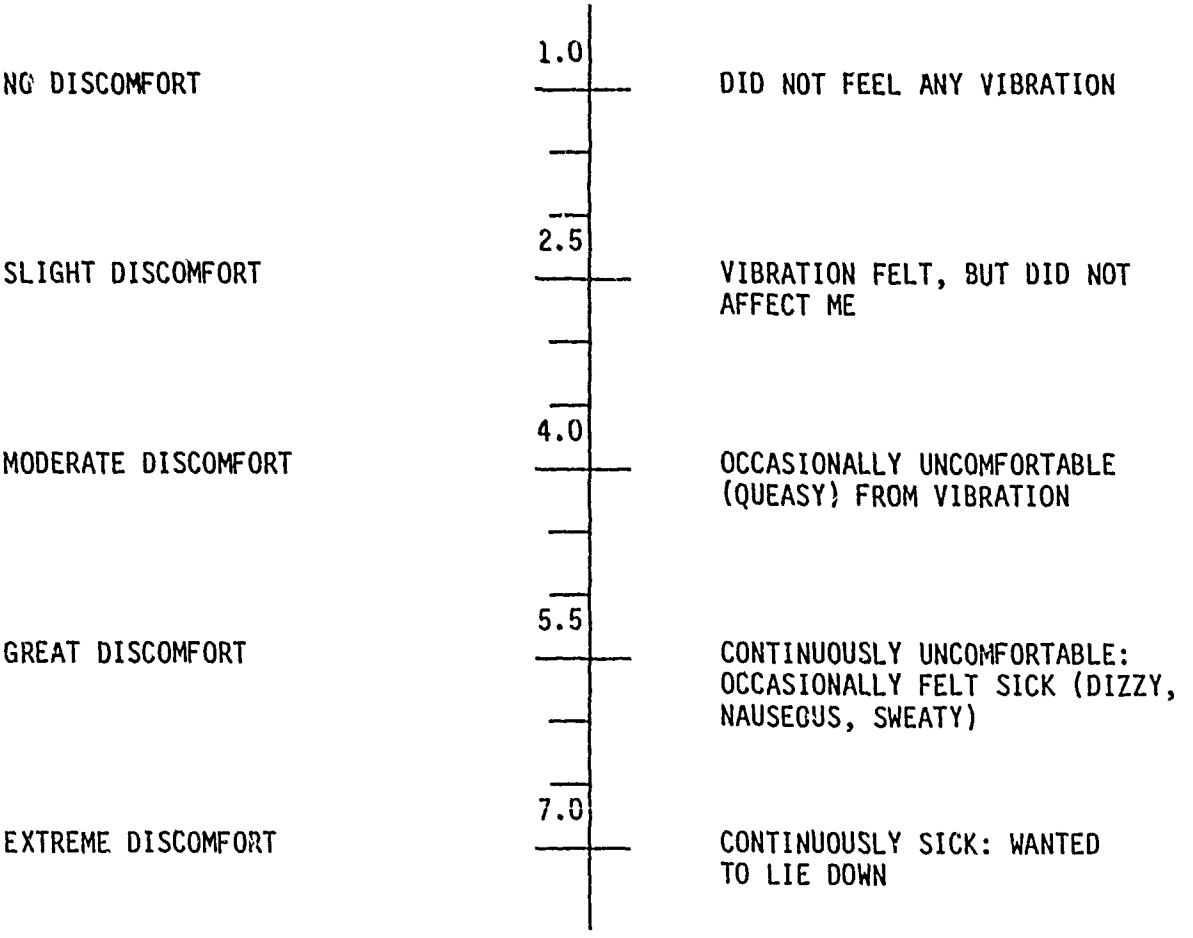
SELF REPORT RATING SCALES
FACTORS 1 - 11

#1

VIBRATION DISCOMFORT RATING SCALE*

RATING ITEM:

Vibration discomfort is any feeling of unpleasant physical sensation experienced by personnel as a direct result of vehicle vibration.



*CHECK ANYWHERE ALONG THE SCALE - PAY ATTENTION TO DESCRIPTORS:

If rating is great discomfort or extreme discomfort, please comment further on reverse.

NAME:_____ DATE:_____

#2

REACTIONS TO ENVIRONMENTAL CONDITIONS (Noise, temperature/humidity)

RATING ITEM: CHECK ANYWHERE ALONG THE SCALE - PAY ATTENTION TO DESCRIPTORS

Rating		Descriptor
	1.0	
Not at all		No discomfort noted; no increase in effort required; no performance impairment.
	2.5	
Slightly		Minimal discomfort; slight increased effort to perform tasks; minimal performance impairment.
	4.0	
Moderately		Moderate increase in effort required and/or some discomfort noted; some performance impairment.
	5.5	
Seriously		Considerable increase in effort required to perform tasks; great discomfort; considerable performance impairment.
	7.0	
Excessively		Maximum effort required to perform tasks and/or extraordinary discomfort; serious performance impairment.

If rating is seriously or excessively, please comment further. (Over)

NAME: _____ DATE: _____

ILLUMINATION

RATING ITEM: CHECK ANYWHERE ALONG THE SCALE - PAY ATTENTION TO DESCRIPTORS

Because of the illumination within the vehicle or operating compartment, tasks requiring fine visual discrimination.

Rating		Descriptor
Excellent	1.0	Can be performed effortlessly.
Good	2.5	Can be performed with only slight effort.
Fair	4.0	Can be performed with moderate effort.
Poor	5.5	Can be performed only with considerable effort.
Unacceptable	7.0	Almost impossible to perform because of inadequate lighting.

If rating is poor or unacceptable please comment further. (Over)

NAME: _____ DATE: _____

HANDLING (flying) QUALITIES OF VEHICLE (HH53)

RATING ITEM:

The handling (flying) qualities* of my (aircraft, HH53 helicopter) were such that

Rating		Descriptor
Excellent	1.0	Little or no effort is required.
Good	2.5	Slight amount of effort is required.
Fair	4.0	Moderate amount of effort is required.
Poor	5.5	Considerable effort is required.
Unacceptable	7.0	Very strenuous effort is required.

If rating is poor or unacceptable please comment further. (Over)

*Defined as ease of turning vehicle (overall flight controls).

NAME: _____ DATE: _____

#5

DISPLAY READABILITY

RATING ITEM:

Were all displays readable from the normal operating position?

Rating		Descriptor
Excellent	1.0	All displays readable without effort.
Good	2.5	One or two displays require slight additional effort to read.
Fair	4.0	All displays readable but some eye straining required.
Poor	5.5	Intensive eye straining required to read some displays.
Unacceptable	7.0	All displays difficult to read even with intensive straining.

If rating is poor or unacceptable please comment further. (Over)

NAME:_____ DATE:_____

CONTROL ACESSIBILITY

RATING ITEM:

Were controls reachable when you were normally seated?

Rating		Descriptor
Excellent	1.0	All controls reachable without effort.
Good	2.5	A few controls require slight effort to reach.
Fair	4.0	All controls are reachable with some additional effort.
Poor	5.5	Considerable straining required to reach a few controls.
Unacceptable	7.0	All controls require considerable straining to reach.

If rating is poor or unacceptable please comment further. (Over)

NAME:_____ DATE:_____

#7

CONTROL-DISPLAY ARRANGEMENT

RATING ITEM:

The way controls and displays are arranged on the equipment console is such that operating them was

Rating		Descriptor
Excellent	1.0	Extremely easy and effortless.
Good	2.5	Easy but required a little effort.
Fair	4.0	Slightly difficult, required moderate effort.
Poor	5.5	Very difficult, required considerable effort.
Unacceptable	7.0	Excessively difficult, required strenuous effort.

If rating is poor or unacceptable please comment further. (Over)

NAME:_____ DATE:_____

#8

INFORMATION PRESENTED BY DISPLAYS

RATING ITEM:

Information presented by disolays was

Rating		Descriptor
	1.0	
Excellent		Extremely easy to understand, required almost no effort.
	2.5	
Good		Easy to understand but required a little effort.
	4.0	
Fair		Somewhat difficult to understand, required moderate effort.
	5.5	
Poor		Very difficult, to understand, required very great effort.
	7.0	
Unacceptable		Either extremely difficult to understand or not enough information is available.

If rating is poor or unacceptable please comment further. (Over)

NAME: _____ DATE: _____

#9

COMMUNICATIONS

RATING ITEM:

Intercom/radio messages between personnel are

Rating		Descriptor
Excellent	1.0	Higly intelligible; no distortion at all.
Good	2.5	Fairly intelligible; little distortion.
Fair	4.0	Acceptably intelligible; moderate distortion.
Poor	5.5	Barely intelligible; great distortion.
Unacceptable	7.0	Almost unintelligible; extreme distortion.

If rating is poor or unacceptable please comment further. (Over)

NAME: _____ DATE: _____

#10

OPERATING PROCEDURES OF PAVE LOW III SYSTEM

RATING ITEM:

Operating Procedures of PAVE LOW III system can be understood and followed:

Rating		Descriptor
Excellent	1.0	With no effort or difficulty at all.
Good	2.5	With little effort and difficulty.
Fair	4.0	With moderate effort and difficulty.
Poor	5.5	With great effort and difficulty.
Unacceptable	7.0	With extreme effort and difficulty.

If rating is poor or unacceptable please comment further. (Over)

NAME:_____ DATE:_____

#11

OPERATOR WORKLOAD

RATING ITEM:

My job can be performed effectively

Rating		Descriptor
Excellent	1.0	With no effort or difficulty at all.
Good	2.5	With little effort and difficulty.
Fair	4.0	With considerable effort and difficulty.
Poor	5.5	With great effort and difficulty.
Unacceptable	7.0	With extreme effort and difficulty.

If rating is poor or unacceptable please comment further. (Over)

NAME: _____ DATE: _____

APPENDIX E

SATISFACTION CHECKLIST

On a scale from 0 to 100, where 0 represents complete dissatisfaction and 100 represents complete satisfaction, please check your degree of satisfaction with the following factors:

1.	Vibration	0	25	50	75	100
2.	Noise, temperature/humidity	0	25	50	75	100
3.	Illumination	0	25	50	75	100
4.	Vehicle handling qualities	0	25	50	75	100
5.	Display readability	0	25	50	75	100
6.	Control accessibility	0	25	50	75	100
7.	Control-display arrangement	0	25	50	75	100
8.	Information understandability	0	25	50	75	100
9.	Communications	0	25	50	75	100
10.	Operating procedures	0	25	50	75	100
11.	Operator workload	0	25	50	75	100

Rationale: This scale can be used as a very abbreviated summary of the preceding individual scales but obviously does not provide as much information as the latter. It does not indicate the reason for the respondent's satisfaction/dissatisfaction.

NAME: _____ DATE: _____

APPENDIX F

CRITICAL INCIDENT REPORT

Please report any incident during the operation of PAVE LOW III, as to the helicopter, equipment, FLIR, TF/TA, etc., that resulted or could have resulted in an abnormal or potentially dangerous situation (this includes any equipment malfunction). Please identify incident:

1. Did you have an equipment malfunction during the test?

2. How did you first become aware that a malfunction had occurred? What were the symptoms?

3. When the malfunction occurred did you have enough information to know what caused it?

4. Did you try to troubleshoot the equipment during the test? If not, why?

5. How easy or difficult was the malfunction cause to diagnose?

6. Approximately (to the nearest minute) how long did it take you to determine the cause of the failure? _____

   - to replace the component? _____
   - to check that the equipment was working again? _____

   Do you consider this time excessively long? ___ Average? ___ Short? ___

7. Were there any safety hazards in troubleshooting the equipment? What were these? What caused them? What could be done to eliminate them?

8. Did you ask anyone else's advice while troubleshooting? Did you work as part of a team in repairing the failure?

9. Was the failure successfully cleared up? If not, what happened then?

NAME: _____ DATE: _____

THANK YOU!